THE AMERICAN MINERALOGIST
JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 13 SEPTEMBER, 1928 No. 9

FAMOUS MINERAL LOCALITIES: WODGINA, NORTH WEST AUSTRALIA

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For many years Wodgina as a place name, was known only to a few sheep and cattle breeders and wool buyers, as it is in the midst of a district originally, and still, occupied by sheep and cattle graziers. The discovery of gold at Friendly Creek in 1888, and that of tin at several points in the district in 1902, attracted miners to the spot, and resulted in the detection of tantalum minerals, then only of scientific interest. The invention however of the tantalum lamp materially changed the position, and Wodgina became known throughout the world as the main source of high grade tantalum ore. The replacement of tantalum in lamps by tungsten, and a drop in the price of tin led to the almost complete abandonment of Wodgina by miners. The recent invention of malleable tantalum sheet, and its utilization in the chemical industry has however led to the reopening of the Wodgina mines, which still hold premier place as sources of supply of this rare metal.

FIG. 1.

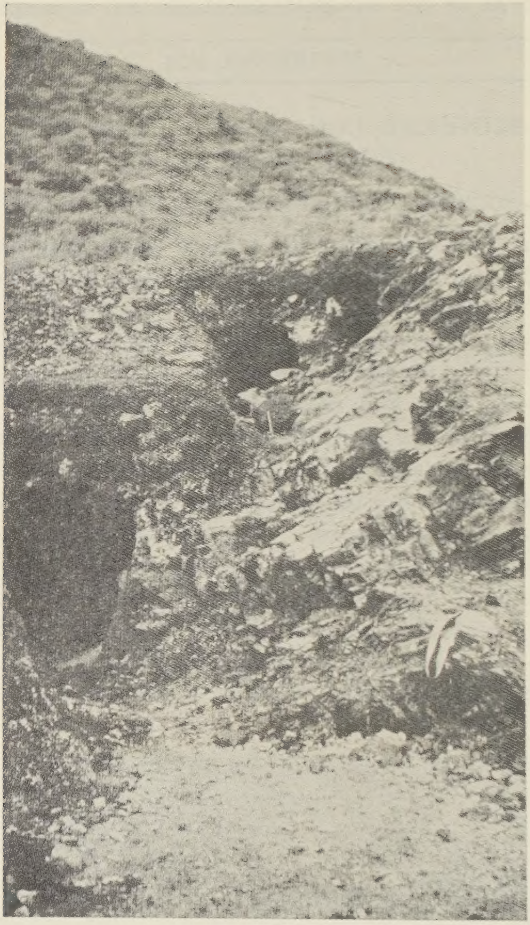

FIG. 2.

To students of historical geology, Wodgina has a special interest because the lead-uranium ratio of one of its minerals fixes the age of the enclosing rocks at 1260 million years, the most extreme age yet determined by this method.[1]

Taking the Wodgina District as embracing an area included in a circle with a center at Mt. Tinstone[2] and a radius of 20 miles.

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[1] A. Holmes. The Age of the Earth, p. 74.

[2] Approximate Lat. 21° 12′ S, Long. 118° 40′ E.

it includes seven mining centers, viz., Wodgina, West Wodgina, Stannum, Mt. Francisco, Abydos, Greens Well, and Friendly Creek. The greater part of this area is occupied by a low sandy coastal plain thickly covered with spinifex grass and sparsely dotted with flowering shrubs and small trees. It is crossed by numerous creeks, dry for most of the year, whose beds reveal the underlying Archaean granite at many points. Low domes of the same rock emerge from the plain at intervals. Rising abruptly out of this plain to heights of 500 to 1000 feet are island hills, five to fifty square miles in area, of Archaean greenstone, the highest points often occupied by jasper bars. The greenstone of the island hills and the granite near them are seamed with pegmatite veins which are homes of the tin and tantalum ores, as well as many other minerals of scientific and industrial interest. Both these veins and the adjacent soils and stream beds have been, and are still being, worked over for cassiterite and tantalite. On the western side of the area quartz reefs are prominent features of the granite-greenstone boundary. They have been worked in the past for gold and copper at Friendly Creek.

The complete list of minerals recorded from this area is as follows:

Bismuth
Gold
Molybdenite
Galena
Chalcocite
Blende
Pyrrhotite
Chalcopyrite
Pyrite
Fluorite
Quartz
Chalcedony and Jasper
Corundum
Hematite
Ilmenite
Spinel
Magnetite
Rutile
Cassiterite
Limonite
Psilomelane

Microcline
Albite
Oligoclase
Labradorite
Hypersthene
Spodumene
Hornblende
Beryl
Helvite
Grossularite
Spessartite
Olivine
Vesuvianite
Topaz
Gadolinite
Metagadolinite
Epidote
Allanite
Hemimorphite
Schorl and Indicolite
Muscovite

Nontronite
Mackintoshite
Thorogummite
Pilbarite^{+}
Hydrothorite^{+}
Microlite
Columbite
Manganocolumbite
Tantalite
Manganotantalite
Calciotantalite^{+}
Tapiolite
Ixiolite
Tanteuxenite^{+}
Monazite
Lithiophilite
Purpurite
Apatite
Autunite
Anglesite

Calcite
Cerussite
Smithsonite
Bismutosphaerite
Malachite
Lepidolite
Biotite
Prochlorite
Talc
Kaolin
Chrysocolla
Ferberite
Scheelite
Ferritungstite
Ferrimolybdite

Of these 77 minerals those marked thus $^{+}$ are species first described as new from this district. Many of the others have not yet been recognized elsewhere in Australia.

A few short notes will explain the occurrence of the minerals.

Bismuth. Alluvial pebbles of native bismuth coated with yellow bismutosphaerite have been picked up with mangano-columbite at Mt. Francisco.

Gold. This is only found at Friendly Creek on the western edge of the area. Originally discovered in 1888, some thousands of ounces were won from quartz reefs in greenstone schist, and from the derived alluvial deposits. A large nugget of 165 Troy ounces was found in 1892 and sold to the Mint for £641.0.0.

Molybdenite and Ferrimolybdite. A few coarse flakes of the sulphide have been found at Mt. Francisco and West Wodgina. At both localities it is associated in quartz with dendritic films of ferrimolybdite.

Galena, Blende, etc. There are no commercial lead or zinc ores in the district, but a little galena, anglesite and cerussite are present in the gold reefs of Friendly Creek. In a quartz reef in granite at West Wodgina finely granular galena is fairly abundant. It is associated with some blende, while close to the surface their place is taken by a mixture of anglesite, cerussite, smithsonite and hemimorphite.

Chalcocite, Chalcopyrite, etc. At Friendly Creek small quantities of these minerals and malachite are present in the gold reefs while quartz veins often carry bunches of richer carbonates and sulphides. At West Wodgina one wall of the galena lode mentioned above carries strings and bunches of chalcocite, malachite and brilliant green chrysocolla.

Pyrrhotite. A little of this is associated with coarse cassiterite in a biotite chlorite schist forming one wall of a pegmatite at Wodgina.

Pyrite. Plentiful in the gold ores of Friendly Creek and distributed throughout the greenstones of the district in small specks.

Quartz and Chalcedony. Quartz veins are not very common in either greenstones or granite except at Friendly Creek. Neither is quartz ever more than a minor constituent of the pegmatites. White chalcedony occurs in several of them, apparently as a replacement of microcline. Immense bands of yellow, brown and grey jasper are conspicuous and plentiful in the eastern half of Wodgina proper, where they often form the highest points of the Archaean greenstone hills. Similar bands are present at Friendly Creek.

Corundum. Magnificent specimens of corundum occur in a narrow band of gneiss in the granite at Abydos. Though nearly every piece is recognizable by its rhombohedral parting and imperfect basal cleavage to be a single crystal individual, the bounding faces are usually imperfect, though the general outline is that of a long tapering bipyramid, either alone or associated with a hexagonal prism. The mineral is subtranslucent and possesses an unusual violet color ranging from Ridgway 57′m through 59″ to 65″ b.

Hematite. Is a constituent in minor amount of the jaspers.

Ilmenite. It occurs as a microscopic constituent of the greenstones and as fine black sand in the alluvium. At Mt. Francisco there is some gravelly ilmenite, probably derived from a pegmatite.

Spinel. This mineral is found in nodules from an ounce or less up to about a pound in weight in a narrow belt of greenstone at Mt. Francisco. It is dark green and transparent in thin section, and has the following composition:

MgO	FeO	MnO	NiO	Fe_2O_3	Al_2O_3	Cr_2O_5	SiO_2	TiO_2	Total	D
14.64	17.42	0.80	0.62	3.96	61.22	nil	1.74	0.09	100.49	3.81

The accompanying minerals are chlorite, talc, biotite, olivine, hypersthene, magnetite, ilmenite and apatite.

Magnetite. Numerous large octahedral crystals are to be seen in a pegmatite vein close to the spinel. Many of the exposed ones are wholly converted into martite. Stream tin ore obtained a few miles further south was contaminated with pea-like grains of magnetite.

Rutile. A few small specimens of black rutile have been found at Mt. Francisco.

Cassiterite. It is a most important mineral throughout the district. The primary deposits are pegmatite veins traversing either granite or greenstone within a few miles of their mutual boundary. The chief component of the pegmatite is albite, followed by microcline and quartz, with minor amounts of spessartite, muscovite, etc. In one mine only, important quantities of tin have been secured from a band of altered greenstone (chlorite biotite schist) adjacent to a pegmatite. From this mine several masses of clean cassiterite, each over 200 lbs. in weight, were obtained. The alluvial deposits derived from the pegmatites are neither deep nor broadly extensive but are still important sources of ore. Cassiterite has been mined at all the centers mentioned and altogether some hundreds of tons have been obtained up to date. Excellent crystals are obtainable at Mt. Francisco, either simple unit bipyramids, or combinations of this with (101). Distortion by elongation parallel to a pyramid edge is common.

Limonite. It is widely distributed in the greenstone country, all the surface of the rocks being stained red-brown with it, while the soil is a limonitic clay loam. Desert polished pebbles of limonite strew the surface in many places and occasionally there is a gossan outcrop to be seen.

Psilomelane. This is the ultimate product of alteration of lithiophilite, and other manganese minerals.

Calcite. No limestones or calcite veins are known, but thin crusts of hard travertine cover an occasional acre or so in the greenstone country, the run off of rain water not being sufficient to carry away all the usually soluble products of rock weathering.

Microcline and Albite. Feldspar veins from 1 ft. to 30 ft. in width are plentiful both in granite and greenstone. The most abundant feldspar in almost every case is albite, usually coarsely crystalline and snow white in color except just on the surface. No specimens were seen illustrating the replacement of microcline by albite, but at times the two feldspars are intergrown, and quite abruptly pure white microcline in coarse crystals will become the predominant constituent of the vein. The feldspar veins are the homes of the valuable tin and tantalum ores, as well as being the matrix of other scientifically interesting minerals.

Oligoclase and Labradorite. These are rock forming minerals only, the former in the granite, the latter in the less altered greenstones (epidiorites).

Spodumene. The writer found this mineral rather plentiful in the tin bearing pegmatite of one vein at Wodgina. It is in flat cleavable plates of pale grey color, reaching a maximum size of about 2×1×0.5 inches.

Hornblende. Dark green hornblende is the chief constituent of the epidiorites, amphibolites and hornblende gneisses which make up the greenstone island hills.

Beryl. This mineral is plentiful in rather well shaped crystals of a pale green color, and from one ounce up to 50 lbs. in weight, in a columbite bearing pegmatite at Mt. Francisco. In one part of the main tantalum lode at Wodgina there are large irregular masses of beryl, translucent and pale milk white in color, and so closely resembling quartz in appearance that for many years it has been mistaken for that mineral.

Helvite. Mr. H. Bowley (Assistant Government Mineralogist) has recently recognized helvite in fairly large masses in pegmatite sent from Mt. Francisco. This is the first time the mineral has been found in Australia.

Spessartite. This garnet is found in several pegmatite veins and the adjacent alluvium at Wodgina, either in large shapeless masses or in smaller well formed crystals. The usual form is (110) bevelled slightly or largely by (211). The color is very pale brown, yellow or pink, but alluvial crystals often have a very thin coat of black psilomelane. A typical unweathered crystal had the following composition:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Total	D
36.03	0.03	20.84	tr.	4.18	37.79	0.19	0.81	99.87	4.16

Vesuvianite. Dense and drusy masses of olive brown vesuvianite have been found at Wodgina and Mt. Francisco where pegmatites cut the greenstones. Typical specimens from the former place show the compact granular mineral passing inwards into dense radiated masses, and thence into short free prisms combining (110), (100) and (001).

Topaz. Only a single specimen of this mineral has been recognized at Wodgina.

Gadolinite. Detrital masses of black glassy gadolinite, thickly coated with brown metagadolinite, have recently been found at

Abydos. The largest one weighed 24 ounces. Under the microscope the mineral is dark green and mostly anisotropic but some specimens are isotropic and others include both types.

Epidote. It is frequently seen in the granite country close to greenstone dykes.

Tourmaline. Fairly large black crystals of schorl are abundant in the greenstone near some of the pegmatite veins at Wodgina and Abydos. Near the spodumene at Wodgina are large dense masses of almost microscopic prisms of indigo blue indicolite.

Muscovite and Biotite. These are rock forming minerals only, except at Mt. Francisco where occasional books of muscovite reach 5 inches in diameter.

Lepidolite. Large bunches of fine scaly lepidolite up to many feet in diameter occur at irregular intervals in the pegmatites at Wodgina. Smaller masses have been seen at Stannum and Mt. Francisco.

Prochlorite. This appears to be the common species of chlorite in the occasional chloritic alterations of the Archaean greenstones.

Nontronite. Yellowish green nontronite forms small seams in partly weathered amphibolite on the east side of Wodgina where the rock is traversed by jasper bars.

Mackintoshite, Thorogummite, Pilbarite, Hydrothorite. These form a genetically related series of minerals of which the parent is the mineral provisionally called mackintoshite though it differs in some respects from the type from Texas. All are massive and isotropic, but while the first two are hard and vitreous, the last two are earthy and much softer. They occur as infrequent "pebbles" in the albite of the main tantalite vein, particularly at its northern end, where they are often associated with lithiophilite. The compositions of the Wodgina minerals are:

	Mackintoshite	Thorogummite	Pilbarite	Hydrothorite
SiO_2	16.19	15.30	12.72	15.77
P_2O_5	n.d.	n.d.	1.08	1.33
K_2O	nil	nil	0.09	nil
Na_2O	nil	nil	0.04	nil
CaO	1.28	1.62	0.57	1.65
PbO	7.90	7.78	17.26	1.25
MgO	0.15	0.16	0.21	0.60
MnO	0.07	nil	nil	nil
FeO	0.20	nil	nil	nil
Fe_2O_3	nil	trace	0.20	nil
Al_2O_3	trace	trace	0.15	0.88
Ta_2O_5	0.67	0.40	0.47	nil
UO_3	present	37.33	27.09	2.98
UO_2	35.60	nil	nil	nil
ThO_2	24.72	24.46	31.34	57.79
Ce_2O_3	0.10	0.12	0.19	0.24
Y_2O_3	0.25	0.32	0.49	0.73
H_2O-	0.88	4.19	3.50	9.12
H_2O+	12.04	8.37	4.16	6.06
CO_2	nil	nil	nil	1.50
Total	100.05	100.05	99.56	99.90
D.	4.45	4.13	4.68	?
R.I.	?	1.617	1.74	1.638

On the basis of the lead-uranium ratios in mackintoshite the age of the Wodgina pegmatite veins has been calculated to be 1260 million years.

So far these minerals have been found in quantities far too small to be used as a commercial source of radium or thorium.

Microlite and Calciotantalite. A few small water worn pebbles of microlite have been collected at Greens Well. These were described in detail in 1907.[3] Their composition is given below with that of a second lime bearing tantalate, also very rare, which appears to be a calciferous tantalite, to which the author has given the name "calciotantalite."

	Ta_2O_5	Nb_2O_5	SnO_2	TiO_2	CaO	FeO	MnO	MgO	K_2O	Na_2O	Ign.	Rare Earths	Total	D
Microlite	73.54	3.62	0.90	n.d.	13.46	3.64	0.60	0.42	0.20	1.66	1.28	nil	99.32	5.42
Calcio-tantalite	73.82	6.44	0.72	0.54	7.78	8.42	1.39	0.62	nil	nil	trace	nil	99.73	6.04

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[3] E. S. Simpson. Tantalum and Niobium in Austraila. *Aust. Ass. Adv. Sci.*, **1907,** p. 450. *Idem,* **1909,** p. 314.

Ferrotantalite and Ferrocolumbite. These are rarities, occasional alluvial pebbles, and lode specimens only having been recorded from Greens Well.

Manganotantalite and Manganocolumbite. These are of common occurrence throughout the district both in pegmatite veins and alluvium, in the latter case often associated with cassiterite. Well over 100 tons of manganotantalite concentrate, assaying 64 to 68 per cent Ta_2O_5 has been marketed. The greater part of this has come from Wodgina itself, with smaller parcels from Greens Well, etc. In the "main tantalite lode" at Wodgina and its adjacent detritus the clean mineral is remarkably uniform in quality, the Ta_2O_5 content running from 68 to 72 per cent, with 12 to 16 per cent of MnO. There is no associated columbite or cassiterite, and the gangue minerals, albite, microcline and quartz, with lesser amounts of kaolin, beryl, spessartite and lithiophilite, are easily separated by jigs and concentrating tables. The largest mass yet recovered from the lode weighed about 40 lbs. One of the most interesting specimens found in the adjacent soil was a well formed twin on (021) weighing 8 lbs. Simple crystals are common, showing the forms (100) (010) (001) and (133).

Minerals rich in tantalic oxide are less abundant both at Wodgina and the outlying mining centers than are ones with less than 52 per cent of Ta_2O_5 and, therefore, properly classified as manganocolumbite. Several deposits in which the mineral carries 40 to 50 per cent Ta_2O_5 are known at Wodgina. At Mt. Francisco an ore is plentiful in a pegmatite in granite about two miles from the greenstone boundary. Two tons of this have been collected from the outcrop. It varies in density from 5.46 to 6.32 indicating percentages of Ta_2O_5 ranging from 12 to 45.

At Abydos there is manganocolumbite with 5 to 18 per cent of Ta_2O_5. Greens Well ore has assayed 45 to 73 per cent Ta_2O_5. (In every case crystals are not at all uncommon.)

Tapiolite. Some small twinned crystals of this mineral found at Greens Well were described by the author in 1917.[4] No further specimens have been collected.

Ixiolite. A manganese tantalate totally different in habit, color and translucency to the normal manganotantalite, has been found in one of the workings on the main tantalite lode at Wodgina.

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[4] E. S. Simpson. On Tapiolite in the Pilbarra Goldfield. *Min. Mag.* **18**, 116-7.

Its composition also is unique, perfectly homogeneous masses carrying 9 per cent SnO_2. Measurable crystals have not been found, but on several other grounds it is classified as ixiolite.[5]

Tanteuxenite. Normal euxenite is a titano-niobate of yttrium. The corresponding titano-tantalate of yttrium, first found at Cooglegong, 55 miles E.S.E., of Wodgina, and later much nearer to that town, at Woodstock, Mt. Francisco and Abydos, has been named "tanteuxenite" by the author. The mineral occasionally exhibits imperfect tabular orthorhombic crystals, is resinous in lustre, light to dark brown in color and breaks with a conchoidal fracture. Its density is notably higher than that of typical euxenite, 5.4 to 5.9, as compared with 4.6 to 5.0. At Abydos and Mt. Francisco it is associated with alluvial cassiterite.

Monazite. Small brown water worn pebbles of this mineral have been seen in alluvial tin from Abydos and Mt. Francisco. Crystals up to 0.5 inch in diameter are not uncommon at the latter place, the usual combination of forms being (100), (110), (121), or (100), (110), $(\bar{1}11)$, or (100), (001), $(\bar{1}01)$, (110), $(\bar{1}11)$.

Lithiophilite and Purpurite. Lithiophilite has been observed by the writer in masses of one pound to ten hundred-weight in pegmatite veins at Wodgina and Mt. Francisco. Close to the surface it is more or less completely altered into a black mass of purpurite and psilomelane. The unaltered mineral is pale grey in color, translucent and exhibiting the typical cleavages. Weathering alters the color first to amber yellow, then to brown with blood red flakes (pure purpurite), finally to black, by staining with psilomelane. Two analyses have been made. (1) is of pale yellow mineral from Mt. Francisco and (2) of a brown mineral with red flakes, an intimate mixture of lithiophilite and purpurite, from Wodgina.

	P_2O_3	MnO	Mn_2O_3	FeO	Fe_2O_3	Co_2O_3	CaO	MgO	Li_2O
(1)	45.99	30.80	—	10.44	—	—	2.78	0.94	7.87
(2)	42.98	22.88	13.44	4.25	2.51	0.10	3.32	0.84	4.50

	Na_2O	K_2O	F	H_2O+	Total	D
(1)	0.34	nil	nil	1.11	100.27	3.39
(2)	0.15	0.05	nil	5.65	100.67	3.24

Some still further altered material contained only 1.55 per cent of Li_2O, with 36.25 per cent of P_2O_5.

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[5] E. S. Simpson. Further Occurrences of Tantalum and Niobium in W. A. *Aust. Ass. Adv. Sci.*, **1909**, 314.

Apatite. Narrow veins of white or pale grey apatite have been observed in several masses of lithiophilite, and there are other masses of similar apatite isolated in the pegmatites of Wodgina and Mt. Francisco. In one pegmatite at Wodgina a large body of lepidolite is dotted with pieces of apatite of a deep greenish blue color (Ridgway 43′m to 45′m).

Autunite. A few minute scales have been observed at the junction of lithiophilite and thorogummite.

Ferberite, Scheelite and Ferritungstite. At Friendly Creek numerous specimens of iron tungstate have been obtained from alluvial concentrates with cassiterite and gold, while scheelite has been found in carbonate copper ore. At West Wodgina scheelite occurs in biotite schist alongside a pegmatite and at Wodgina it is occasionally seen in alluvial tin and tantalum concentrates. Some of the Friendly Creek ferberite is partly replaced by ferritungstite.

XANTHOCONITE AND ASSOCIATED MINERALS FROM THE GENERAL PETITE MINE, ATLANTA DISTRICT, IDAHO

EARL V. SHANNON,[1] *U. S. National Museum.*

The exceedingly rare mineral xanthoconite has the formula $3Ag_2S \cdot As_2S_3$ and is, therefore, a dimorphous form of the same compound as proustite. An antimonial analogue of xanthoconite is known in the mineral pyrostilpnite or fireblende, corresponding in composition with pyrargyrite. Dana gives the crystal form of xanthoconite as rhombohedral and mentions the Himmelsfürst mine, near Freiberg, as the only locality. This symmetry was given by Breithaupt and was determined on fragments of a single crystal which had been broken into several pieces before measurement. The material occurred associated with proustite, the xanthoconite making up reniform masses with a surface consisting of microscopic crystals, and with a crystalline-granular interior. The specimen was mined in 1797 and described from the Berg-Akademie collection in 1840.

In 1893 Miers[2] published an exhaustive examination of this mineral which proved the identity of xanthoconite and rittingerite. The occurrence of the mineral at several European localities—Freiberg, Johanngeorgenstadt, Rudelstadt and Markirch, Elsass, as well as Chañarcillo, Chile, is established. The crystallography is discussed at length and it is shown that the mineral is monoclinic, usually thin tabular parallel to *c*(001), and that the crystals are most frequently composed of overlapping plates, which are also twinned, united by the face *c*. The identity in geometrical form with pyrostilpnite is demonstrated.

The first mention of the occurence of xanthoconite in North America is by Browne[3] who in 1868 stated that "xanthocone" was one of the silver minerals present in rich ores of the Flint district in Owyhee county, Idaho. In the work on the minerals of that State[4] no trace of this mineral was found nor any further reference to it. The only reason for seriously crediting Browne's report was that he was well acquainted with silver minerals and, having been educated at Freiberg, was doubtless familiar with the type specimens of xanthoconite in the Berg-Akademie's collection.

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[1] Published by permission of the Acting Secretary of the Smithsonian Institution.

[2] H. A. Miers. Xanthoconite and rittingerite, with remarks on the red silvers. *Mineralog. Mag.*, **10**, pp. 185-216, 1893.

[3] J. Ross Browne. *Mineral Resources U. S.* for **1868**, p. 528.

[4] Earl V. Shannon. The minerals of Idaho. *U. S. National Museum Bulletin* **131**, 1926.

The second North American locality for this mineral, mentioned in the literature, is the La Rose mine at Cobalt, Ontario. This was described by Parsons[5] in 1924. The single specimen from this locality is described as having the xanthoconite in the form of buffy-brown, approximately hemispherical radiated aggregates, and a few isolated crystals associated with proustite.

In view of the rarity of the mineral the writer was much interested to find in the Roebling collection a specimen of xanthoconite from a second locality in Idaho. The label accompanying this specimen states that it was purchased from Lazard Cahn and was found in 1908 at the General Petite mine in the Atlanta district in Elmore county. This district is almost exactly 100 miles in an air line from the district in which the mineral was reported by Browne.

The small specimen consists chiefly of a mass of lustrous argentite, without crystalline boundaries, containing small and perfect embedded prismatic crystals of colorless quartz. Even where their bases are embedded in solid argentite, the quartz crystals are broken across at one end showing that they were formed and broken loose from their point of attachment before deposition of the silver sulphide. The argentite thus forms an abundant matrix for a breccia of euhedral quartz crystals. Molds left by removal of the quartz crystals show thin yellow smears which are apparently native gold. Proustite, argentite, arsenopyrite and polybasite, in small perfect crystals rest upon the massive argentite, and the xanthoconite forms hemispherical masses up to 2 millimeters in diameter deposited around, and apparently later than, the proustite. The order of genesis of the minerals of the specimen is then:

1. Quartz
2. Gold
3. Argentite ⎧ Argentite
4. Proustite ⎨ Arsenopyrite
5. Xanthoconite ⎩ Polybasite

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[5] A. L. Parsons. Xanthoconite from Cobalt, Ontario. Contributions to Canadian mineralogy, 1924. *Univ. Toronto Geological Series*, No. 17, pp. 11-12, 1924.

The hemispherical masses of xanthoconite are golden yellow to brownish-yellow in color, and are crystalline-granular within and covered on the outside with very thin tabular crystals not exceeding 0.1 millimeter in greatest diameter. In general they have a thickness of 0.01 millimeter or less. It will be noted that in color, in the tendency to aggregation into crystalline-granular drusy hemispherical or mammillary forms, and in its association with proustite, the Idaho xanthoconite of this occurrence is almost identical with the original specimen from the Himmelsfürst mine, Saxony, and with the material from Cobalt, Ontario.

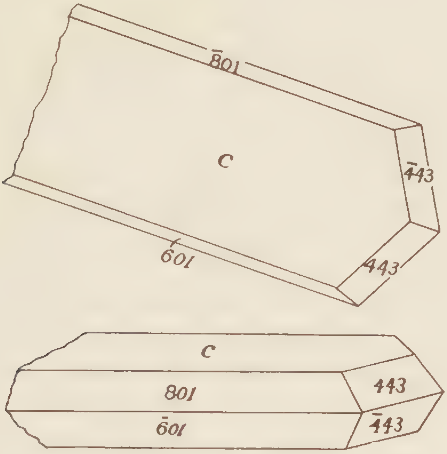

Fig. 1. Xanthoconite.

The Idaho xanthoconite crystals are almost entirely unsuited for goniometric study. They are very minute and exceedingly thin and the faces are imperfect. Further, the larger crystals are compound, being made up of several individuals which are not quite in parallel position. In addition to being almost too small to handle they are so flexible and fragile that they are invariably either bent or shattered in detaching them from their matrix. One which was set up with the broad face *c*(001) in the polar position gave no reflections from other faces. Another which was set up with the *b* axis vertical had the form and appearance of figure 1. This gave confused groups of signals from the two faces of *c*(001). Reflections but no signals were obtained from four orthodome faces. One of these, taken as positive, gave an angle from the base of 72½°, which is near (601), the rho (ρ) angle for which is 72°38′ ($001 \wedge 601 = 71°25''$). The negative dome gave an interfacial angle of 77° which roughly corresponds to −80 ($\bar{8}01$), the rho (ρ) angle for which is 76°46″($001 \wedge \bar{8}01 = 77°59'$). The positive pyramid reflecting corresponded very roughly with (443) Goldschmidt and, from its relative position, the other was assumed to be ($\bar{4}43$).

Optically examined under the polarizing microscope the euhedral crystals are yellow in color and not noticeably pleochroic. They show very high refractive indices and moderately high birefringence. Euhedral crystals lying on the flat side show a bisectrix perpendicular to *c*(001), with large axial angle and the optic plane parallel to the elongation which is positive. Assuming that this is the acute bisectrix, 2E is very large and the mineral is optically negative, the orientation being X near *c*, Y = near *a*, Z = *b*.

The proustite forms very brilliant, transparent, red crystals not exceeding 1.5 millimeters in length resting upon the argentite, either singly or in small divergent groups. In one case a cruciform penetration twin was seen but was not measured. Despite the excellent appearance of the crystals, they were not well suited for crystallographic measurement as the signals are blurred and multiplied by striations. The faces also were rounded. The crystals are short, prismatic and terminated by faces of three rhombohedrons, the form and habit being as shown in figure 2. The angles measured are as follows:

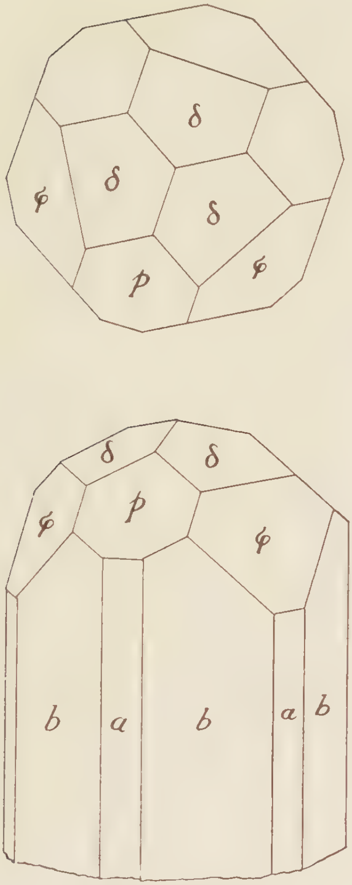

FIG. 2. Proustite.

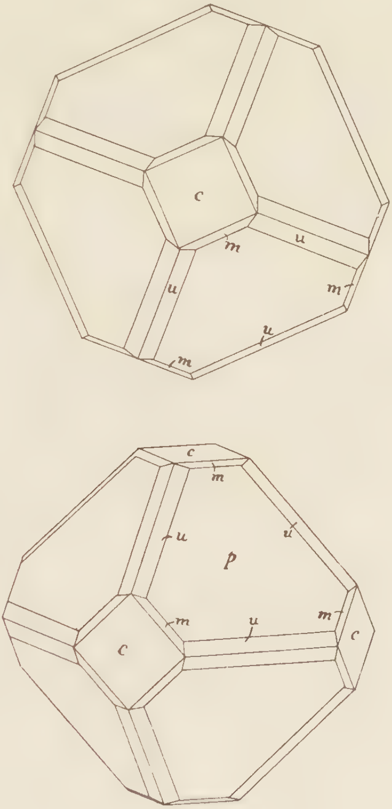

FIG. 3. Argentite.

MEASUREMENTS OF PROUSTITE CRYSTAL

No.	Form Letter	Symbol Gdt.	Symbol Miller	Quality Description	Measured φ	Measured ρ	Calculated φ	Calculated ρ
1.	a.	∞0	$10\bar{1}0$	Poor	0°19′	90°00′	0°00′	90°00′
2.	b.	∞	$11\bar{2}0$	Poor	30°29′	90°00′	30°00′	90°00′
3.	p.	+1	$11\bar{2}1$	Very poor, striated	32°13′	41°53′	30°00′	42°18′
4.	δ	$-\frac{1}{2}$	$\bar{1}\bar{1}22$	Poor	30°00′	24°00′	30°00′	24°28′
5.	φ	−2	$\bar{2}\bar{2}41$	Good	30°00′	62°08′	30°00′	61°12′

Although the main mass of the argentite forming the core of the specimen is without crystal form, there occur rarely on this, or attached to a quartz crystal, some scattered very minute but highly perfect and lustrous black argentite crystals. One of these which was measured showed the forms and angles of figure 3. The average diameter of these argentite crystals is only about 0.2 millimeter. Attached to the argentite crystal that was measured were some very minute, long prismatic crystals of arsenopyrite. The argentite crystal, which is figured, gave the following angular measurements:

MEASUREMENTS OF ARGENTITE CRYSTAL

	Form	Symbol		Quality	Measured		Calculated	
No.	Letter	Gdt.	Miller	Description	ϕ	ρ	ϕ	ρ
1	*c*	0	001	Excellent	—°—′	0°00′	—°—′	0°00′
2		0 ∞	010	Excellent	0°03′	90°00′	0°00′	90°00′
3	*p*	1	111	Excellent	45°08′	54°32′	45°00′	54°44′
4	*m*	$\frac{1}{3}$	113	Poor	45°08′	24°38′	45°00′	25°14′
5		13	131	Very poor	19°10′	72°00′	18°26′	72°27′
6	*n*	$\frac{1}{2}$1	122	Poor	26°53′	48°06′	26°34′	48°11′
7		2	221	Very poor	45°08′	70°00′	45°00′	70°32′

In addition to the rare argentite crystals there also occur, resting upon the massive argentite, very minute lustrous black, hexagonal, tabular crystals of polybasite. These give reactions for sulphur, antimony and silver and negative reactions when tested for arsenic. They are very minute. One which was measured had the form shown in figure 4. This was 0.6 mm. broad with a thickness of 0.2 mm. The basal pinacoid was striated in three directions as shown in the drawing. The angles measured are compared with the angles for this mineral given in Goldschmidt's Winkeltabellen.

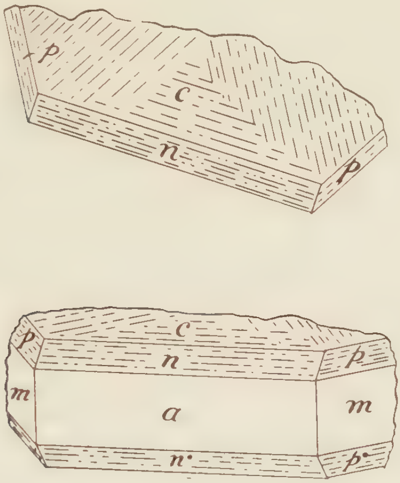

Fig. 4. Polybasite.

MEASUREMENTS OF POLYBASITE CRYSTAL

No.	Form Letter	Symbol Gdt.	Symbol Miller	Quality Description	Measured φ	Measured ρ	Calculated φ	Calculated ρ
1	*c*	0	001	Poor	—°—′	0°00′	—°—′	0°00′
2	*m*	∞	110	Good	30°32′	90°00′	30°01′	90°00′
3	*a*	∞0	100	Poor	90°00′	90°00′	90°00′	90°00′
4	*n*	10	101	Very poor	89°32′	43°12′	90°00′	42°23′
5	*p*	1	111	Very poor	29°29′	62°17′	30°00′	61°16′

The occurrence of so large a number of minerals in one small specimen is very unusual. Of these the age relationship between quartz, massive argentite, proustite and xanthoconite, as stated above, is clear. The proustite, crystallized argentite, polybasite, and arsenopyrite are not in such a position with reference to each other that their paragenesis can be determined. They may be more or less contemporaneous. The whole assemblage is doubtless epigene, and not in any sense due to secondary downward enrichment.

GYPSUM AND ANHYDRITE

FRANK A. WILDER, *North Holston, Virginia.*

On account of its importance in the building industry gypsum ranks as one of the most important non-metallic minerals. The output in 1926 was 5,635,441 tons[1]. Included with the mineral reported as gypsum was a small amount, perhaps 200,000 tons, of anhydrite.

Although there are extensive bibliographies dealing with gypsum and anhydrite[2], little has been said about the fact that many important gypsum deposits were originally anhydrite[3].

The growing importance of the gypsum beds of Nova Scotia, from which large quantities of the mineral are shipped to cities on the Atlantic seaboard, has led to careful study of these deposits and to considerable core drilling, and it seems safe to make certain generalizations based on the data thus derived. The relationships existing between gypsum and anhydrite in Nova Scotia seem to characterize also the deposits in New Brunswick, Newfoundland, and Prince Edward Island.

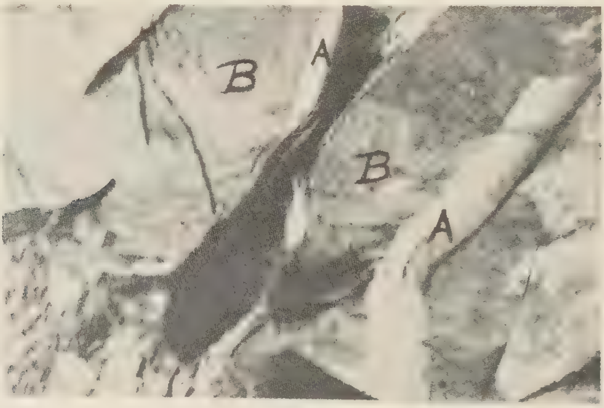

FIG. 1. Gypsum veins (A) in anhydrite (B) at cliff near mouth of Grand Codroy River, Newfoundland.

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[1] Statistics of *Bureau of Mines*, quoted in article on Gypsum in *Mineral Industry*, Vol. XXXV, 335, 1927.

[2] The writer in a monograph on gypsum published by *Iowa Geological Survey* (Vol. 37, pp. 44-536), lists 900 titles, and the Department of Gypsum and Lime, *Bureau of Standards*, has a card index of nearly 5000 titles.

[3] The possibility of a change from anhydrite to gypsum has recently been mentioned by Oliver Bowles and Marie Farnsworth, *Economic Geology*, Vol. 20, No. 8, Dec. 1925.

In Nova Scotia anhydrite is generally found underlying the gypsum and very often the gypsum merely forms a veneer varying in thickness from a few inches to a few feet, over the anyhdrite. At times the gypsum extends to a considerable depth and the anhydrite rises in dyke-like bodies through the gypsum. More rarely the anhydrite is cut by veins of gypsum which run irregularly through the anhydrite which may be quite free from bedding planes. Figure 1 shows a portion of a natural exposure of gypsum and anhydrite that occurs near sea level at the mouth of the Grand Codroy river in Newfoundland. The greater part of the exposure consists of practically pure anhydrite. Running through this mineral are irregular veins of gypsum varying in thickness from two to six inches. It seems to be a fair inference that the whole mass was originally anhydrite and that water following along cracks has converted a limited portion of the anhydrite into gypsum. The conditions shown in figure 1 which characterize the entire exposure seem to make any other explanation difficult.

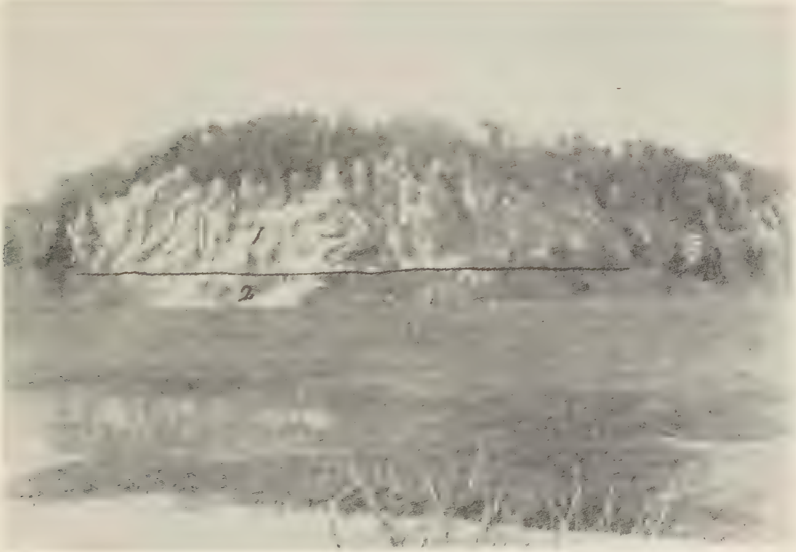

Fig. 2. Cliff at Cape North, Cape Breton, Nova Scotia, showing gypsum (1) and anhydrite (2).

It is of course well known that anhydrite slowly changes to gypsum under ordinary atmospheric conditions and in normal exposures the change is hastened by cracks which permit the penetration of surface waters. The change from anhydrite to gypsum would doubtless be observed frequently were it not for the fact that the solubility of gypsum is considerably greater than that of anhydrite and often the gypsum is carried away in solution as rapidly as it is formed.

Attempts have been made by the non-metallic section of the Bureau of Mines to convert anhydrite into gypsum on a commercial scale. The process involves the fine grinding of anhydrite with subsequent agitation in water and would be successful if gypsum did not exist naturally in large bodies so located that the cost of freight from such locations is less to all important markets than the cost of transforming anhydrite into gypsum.

The following letter from Southern Drilling Company, of Saltville, Virginia, indicates conditions which prevail generally throughout Nova Scotia:

Saltville, Va.
Nov. 3, 1927

DR. FRANK A. WILDER, Consulting Geologist,
Beaver Products Company, Inc.,
North Holston, Virginia.

DEAR DR. WILDER:

Regarding the gypsum drilling done by our company in Nova Scotia during the summer of 1926, and with reference to the anhydrite encountered, I wish to say that on the Cape North property, Victoria County, Cape Breton, the anhydrite was shown to underly the entire area of this deposit.

One drill hole, located at very low elevation, showed, after passing through about twenty-five feet of very fine quality gypsum, two hundred and seventy-five feet of massive anhydrite. The hole was discontined at this depth.

At one point, affected by the action of a small river, a clearly defined contact between the gypsum and anhydrite is shown. (Figure 2). This massive anhydrite flooring, so clearly exposed at this point, connected up by subsequent drilling data, is shown to lie very flat, dipping slightly north west.

Hoping this information may be of some interest, I am,

Yours very truly,

B. A. CHAPPEL

At least half of the gypsum deposits of the United States are associated with anhydrite. As a rule the anhydrite increases with the depth of the deposit. Interesting examples occur at

Centerville, Iowa, and in Smyth County, Virginia. In both of these deposits the original mineral appears to have been anhydrite which in some places has been wholly changed to gypsum while elsewhere it has been only partially altered. Figure 3 furnishes an interesting example from the mines at North Holston, Virginia. In this figure the fine grained background or matrix is anhydrite. The distinct crystals or phenocrysts are most abundant along small cracks in the anhydrite and are often dark in color due to the presence of some carbonaceous material. A block of the mineral that is quite dark becomes almost white when heated to 500°C.

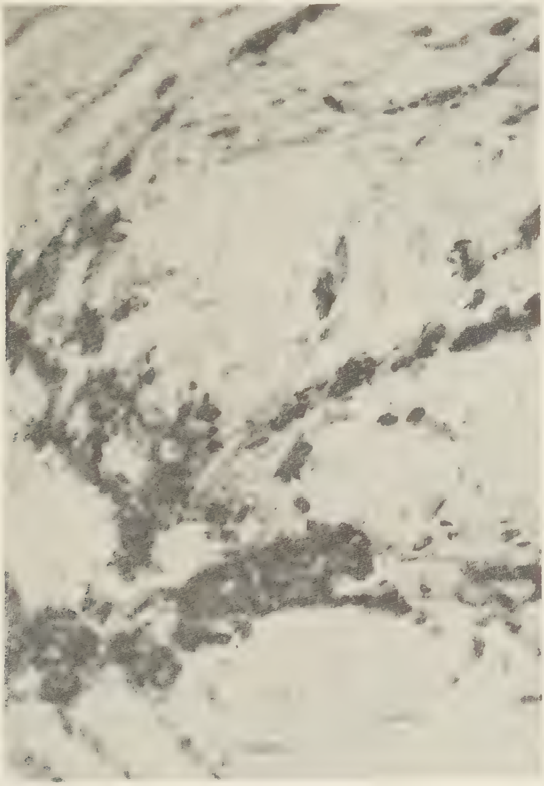

Fig. 3. Phenocrysts of gypsum in fine grained anhydrite matrix. In places along cracks they are darkened by bituminous matter.

Often large masses are found in which the gypsum phenocrysts predominate, the fine grained anhydrite merely filling the spaces between the crystals.

From a practical point of view the association of anhydrite and gypsum is of the utmost importance. Since anhydrite lacks water of crystallization it cannot be changed to the hemi-hydrate by calcination. As is well known most of the gypsum used in building construction is calcined at moderate temperatures (usually 340°F.) after fine grinding. Calcined gypsum is plaster of Paris, though only a limited amount of the whitest material is put on the market under this name.

Most of the gypsum that is calcined is used in the manufacture of interior plasters. For this purpose a retarder is added so that the setting time of the plaster, when mixed with two parts of sand, is about five hours. Anhydrite and gypsum—anhydrite mixtures, are finely ground for use in agriculture, and are acceptable as retarder for cement by most cement mill chemists. Some clinkers high in alumina do not seem to be satisfactorily retarded by pure anhydrite. Gypsum-anhydrite mixtures, however, in which gypsum equals 40 per cent of the total, will satisfactorily retard cements with alumina content as high as 7.5 per cent.

Both gypsum and anhydrite, as well as gypsum-anhydrite mixtures, are useful in agriculture, for redeeming black alkali soils and as a source of sulphate sulphur in soils that may be deficient in this substance. The economic importance of gypsum, however, will probably be found in the future, as at present, in the usefulness of the calcined mineral in building construction, and for this reason a careful study of the relationships between gypsum and anhydrite is of the utmost importance.

THE CHEMICAL FORMULA OF BORACITE

JOHN W. GRUNER, *University of Minnesota.*

The chemical formula $Mg_7Cl_2B_{16}O_{30}$ was assigned to boracite almost seventy years ago[1]. In spite of the great attention which this orthorhombic mineral has received on account of its optical behavior and its inversion at 265°C. to the cubic system, no new chemical analyses of boracite seem to have been made[2].

Some months ago the writer started an investigation of the structure of boracite. He is much indebted to Professor E. Schiebold and Professor F. Rinne in Leipzig, in whose laboratories the X-ray work was carried on. It was noticed early in the work that the dimensions of the unit cell, as determined by the oscillation method (Seeman-Schiebold), do not permit the placing of an even number of molecules into the cell. Precision measurements with calcite as standard were made on colorless crystals from Westeregeln and greenish ones from Solvey. The dimensions of the orthorhombic cell of the colorless crystals are: $a_0=b_0=16.97$Å. There is no noticeable difference in the lengths of the a and b axes. Referred to the cubic orientation they are the [110] and [$\bar{1}$10] directions, respectively. c_0 (the [001] direction in the cube) is 12.00Å in length. For the greenish crystals the dimensions are: $a_0=b_0=17.11$Å and $c_0=12.10$Å.[3] Density determinations were checked by the writer and found to vary between 2.92 and 2.97 for the colorless and 2.97 to 3.10 for greenish boracite.

The well-known equation,

$$\text{number of molecules} = \frac{\text{volume in Å}^3 \times \text{density}}{\text{molecular weight} \times 1.64 \times 10^{-24}}$$

for the determination of the number of molecules in the unit cell gives values varying from 7.0 to 7.3, when allowance is made for the increase in molecular weight with increase in ferrous iron. Symmetry considerations do not permit the placing of seven molecules into a unit cell. Since the dimensions of the cell and density measurements are correct to within a small limit of error, the writer concluded that the formula might be wrong.

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[1] Heintz, W., *Jour. prakt. Chem.*, vol. **77**, p. 338, 1859.
Potyka, J., *Poggendorff Annalen*, vol. **107**, p. 433, 1859.

[2] Doelter, C., *Handbuch der Mineralchemie*, vol. **9**, p. 418, 1922.

[3] Rinne has found the same dimensions in a powder diagram. See "Röntgenographische Untersuchungen an einigen feinzerteilten Mineralien," *Zeitsch. f. Krist.*, vol. **60**, pp. 55-69, 1924.

It was found that former analysts[4] had subjected the boracite to long leaching in order to remove any water soluble chlorides and sulfates. Even then the chlorine found was usually about one half per cent higher than necessary for the formula according to Heintz[5].

The writer wishes to thank Mr. George Ward of the Department of Geology and Mineralogy of the University of Minnesota for a new analysis of boracite. The sample of one gram consisted of about 25 good dodecahedral and cubic colorless crystals from Eime, near Hanover, Germany. The finely ground sample was divided for duplicate analyses. The powders were put into beakers with 100 c.c. of distilled water for 48 hours. Precautions were taken not to contaminate the samples or filtrates by gaseous chlorine or HCl from the air of the laboratory. The water was then carefully decanted through a filter paper. The filtrates were analyzed for chlorine and gave 0.05 per cent and 0.06 per cent Cl, respectively. These almost negligible amounts have been added to the total Cl in the analyses below.

The powder in the beakers was dried at 105°C. for several hours, weighed and fused with sodium carbonate. The chlorine was determined as AgCl volumetrically, as well as gravimetrically for a check. Standard methods were used. The amount of ferrous iron was practically negligible. The trace of it was weighed with the magnesium. Boron was calculated by difference.

TABLE I.

	NEW ANALYSES			THEORETICAL COMPOSITIONS FOR		
	I	II	Average	$Mg_7Cl_2B_{16}O_{30}$	$Mg_3ClB_7O_{13}$ or $Mg_6Cl_2B_{14}O_{26}$	$Mg_{25}Cl_8B_{56}O_{105}$
$MgCl_2$	12.50	12.19	12.35	10.62	12.14	11.99
MgO	26.42	26.36	26.39	26.96	25.70	26.64
B_2O_3	61.08	61.45	61.26	62.42	62.16	61.37
FeO	trace	trace	trace			
	100.00	100.00	100.00	100.00	100.00	100.00

The two analyses and their averages are given in Table 1. The theoretical percentages in the old formula of $Mg_7Cl_2B_{16}O_{30}$ and those in the two new possible ones are found in the three last columns of the table. The last formula $Mg_{25}Cl_8B_{56}O_{105}$, though closely approximating the chemical analyses, is of such proportions that it is difficult to believe it correct. Only two of these large molecules could have room in the unit cell. The exact value is 1.936 molecules which is very close to 2. The formula $Mg_6Cl_2B_{14}O_{36}$, while not in such excellent agreement with the MgO of the analyses, gives us a very good value of 7.845 for the unit cell. Eight of these molecules could be accommodated in the unit cell.

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[4] *op. cit.*

[5] *op. cit.*

This new formula can be written as a combination of a tetraborate and metaborate with $MgCl_2$ as follows:

$$2MgB_4O_7 \cdot 3MgB_2O_4 \cdot MgCl_2$$

or as a double salt of $MgCl_2$ and heptaboric acid $7B(OH)_3$,

$$2\,[7B(OH)_3] - 8H_2O = 2H_5B_7O_{13}\cdot$$

Substituting Mg_5 for $2H_5$ and adding $MgCl_2$ we have the molecule

$$Mg_5B_{14}O_{26} \cdot MgCl_2\cdot$$

A still simpler formula can be written when $Mg_6Cl_2B_{14}O_{26}$ is divided by 2. $Mg_3Cl\ B_7O_{13}$ could be written as a double salt of metaborate and boron-oxychloride[6], thus:

$$3MgB_2O_4 \cdot BOCl\cdot$$

If boracite is orthorhombic hemimorphic, however, as is claimed, then this formula with 16 molecules in the unit cell will probably have to be doubled. This will be discussed in a paper on the structure of boracite.

Conclusions. X-ray diffraction measurements have shown that boracite can not have the formula $Mg_7B_{16}O_{30}Cl_2$ which has been thought correct for many years.

New analyses and re-examination of the old ones show a larger chlorine content in the mineral than given in the old formula. Two new formulas are possible, $Mg_{25}Cl_8B_{56}O_{105}$ and $Mg_6Cl_2B_{14}O_{26}$. The first has such a large molecule that it does not seem reasonable to assign it to boracite. The second one is more probable. It may be possible to write this formula $Mg_3Cl\ B_7O_{13}$, if boracite is orthorhombic holohedral instead of hemihedral hemimorphic as has been claimed.

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[6] For BOCl see: Dammer, O., *Handbuch der anorganischen Chemie*, vol. 3, p. 65, 1893.

EUXENITE FROM SABINE TOWNSHIP, NIPISSING DISTRICT, ONTARIO

H. V. Ellsworth, *Canada Geological Survey.*[1]

Euxenite, next to allanite, is the commonest rare element mineral in Canadian pegmatites. This particular occurrence was studied because it represents a new area in central Ontario, consists of unusually fine material, and was obtained in considerable quantity. It occurs in a pegmatite worked for feldspar, on lot 28, conc. I, Sabine Township, Nipissing District. The property is reached by a mine road which connects with the Trenton-Bancroft line of the Canadian National Railways near mile 113, which is about 3 or 4 miles north of Lake St. Peter station.

The dike in which the euxenite occurs is 12 to 20 feet wide and outcrops at intervals for a distance of 1000 feet or more, extending into lot 29. The strike is about N 60°F mag. and it probably dips to the north. The feldspar working is on lot 28. There is nothing particularly noteworthy about the dike. It is the ordinary microcline-quartz type common in Ontario, consisting for the most part of a coarse graphic intergrowth of quartz and microcline, with occasional patches of microcline crystals, not usually over 1×3 feet, from which commercial feldspar was obtained at the expense of considerable hand cobbing. Very little plagioclase was seen in the working. Biotite was abundant, muscovite was not seen. Nodules, up to 1 inch diameter, of what was supposed at the time of the visit to be magnetite or ilmenite were common. Closer examination of some of this material in the laboratory, however, shows that it is martite. It is non-magnetic, has a reddish streak and contains by a rough qualitative test not over one per cent TiO_2. On reducing it to a powder occasional grains present impart a blackish hue to the predominant hematite color and are feebly magnetic. It seems likely that this material was originally magnetite which has been transformed to hematite. In some specimens what appears to be the magnetite cleavage is retained.

The euxenite occurs chiefly as masses up to four inches in diameter, often associated with biotite, in microcline which is considerably fractured and reddened by iron rust for a radius of a foot or more from the euxenite. The euxenite masses consist of the pure solid mineral uncontaminated by intergrowths of other minerals and are really aggregates of large crystals grown together, the outer surfaces often bearing good crystal faces. Some small individual crystals were also seen. Sometimes a martite nodule may be in contact with the outer surface of the euxenite masses. The feldspar surrounding the euxenite, though badly fractured and stained red, presumably by iron, appears to be typical microcline. When crushed and examined in oil under the microscope practically all grains show the microcline twinning and all have indices less than 1.530, but when examined as hand specimens under the binocular microscope a few scattered minute perthitic intergrowths of plagioclase were seen, which it was estimated would constitute not more than one per cent of the whole.

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[1] Published by permission of the Director of the Geological Survey of Canada.

No large masses of quartz were exposed. There is some smoky quartz but it is not deeply colored. At the time of the writer's visit a cut 4-5 feet deep had been made over a length of 30 feet and four carloads of feldspar had been shipped.

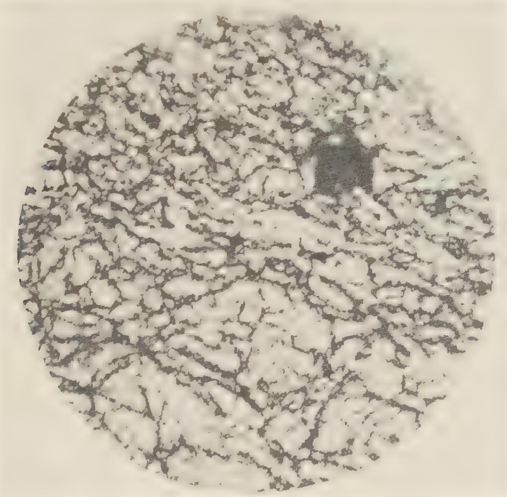

Fig. 1. Highly magnified photograph by transmitted light of a thin section of Sabine township euxenite, showing regular fracturing and freedom from inclusions. The black spot represents a hole in the section. The photograph does not give a true picture of the section. Actually the fractures are very narrow and sharp with little or no alteration along the edges.

The euxenite is pure black en masse, reddish brown, transparent, and isotropic in thin splinters, grains or sections under the microscope. The powder is yellowish brown. It has an unusually brilliant, mirror like, vitreous lustre. It lacks cleavage and has a subconchoidal fracture. It is very brittle with a hardness of 6.5. Sp. Gr. = 5.002. In thin sections under the microscope it appears to be perfectly pure and homogeneous and unusually free from evidences of alteration, such as bleaching or visible decomposition along the edges of fractures. The mineral is intensely fractured (Fig. 1), as are all minerals of this sort, and in a rather more uniform and regular way than is commonly the case. It seems likely that the fracturing seen here is almost entirely due to the increase in volume resulting from autoxidation. Shearing and normal alteration have had but little part in producing the fractures. This view might be criticized on the ground that common minerals such as, apatite, tourmaline, garnets, etc., enclosed in similar Precambrian pegmatites are also usually much fractured. The difference lies in the fact that the radioactive minerals are always very much more intensely and more regularly fractured, and on a much more minute scale than are the common minerals. Even a mineral so soft and brittle as apatite is never fractured to a degree remotely comparable to the complete microscopic shattering always seen in uranium and thorium minerals.

The sample used for analysis was hand picked under the binocular microscope and consisted of the most brilliant material, absolutely free from visible impurities. The analysis yielded the following results:

EUXENITE FROM SABINE TOWNSHIP, NIPISSING DISTRICT, ONTARIO

	Per Cent	Mol. Wt.	Bases	Acids
PbO	1.35	222	0.0061	
(Pb = 1.25)				
UO_2	8.61	270.2	0.0318	
UO_3	0.20	286.2	0.0007	
U = 7.76 = 9.15U_3O_8				
ThO_2	3.94	264	0.0149	
Th = 2.46x0.38 = 0.93 U equivalent				
$(Ce,La,Di)_2O_3$	0.44	330	0.0013	
$(Yt,Er)_2O_3$ (At. Wt. 108)	24.31	264	0.0921	
FeO	0.00	72		
Fe_2O_3	2.07	159.7	0.0130	

MnO	0.28	70.9	0.0040	
Al_2O_3	0.26	102.2	0.0026	
BeO		25.1		
CaO	1.92	56	0.0343	
MgO	0.03	40.3	0.0007	
Na_2O	0.17	62	0.0027	
K_2O	0.04	94	0.0004	
ZrO_2	0.05	122.6		0.0004
SnO_2	0.07	150.7		0.0005
TiO_2	22.96	80.1		0.2866
Ta_2O_5	2.65	443		0.0060
Cb_2O_5	28.62	266.2		0.1075
SiO_2	0.09	60.3		0.0015
$H_2O-110°$	0.08		0.2046	0.4025
$H_2O+110°$	2.15	18	0.1200	
He, etc.	Not determined			

Sp. Gr. = 5.002 at 20.30°

$$\frac{Pb}{U+0.38\ Th} = 0.144$$

The small amount of silica present indicates that the mineral has suffered but little normal alteration and the lead ratio is only slightly lower than that (0.15) of the best uraninites of the Ontario Precambrian.

As the ratio of $Cb_2O_3+Ta_2O_5 : TiO_2 = 1:2.5$ the mineral is to be classed as euxenite, following the suggestion of W. E. Brögger that the name euxenite be applied to those minerals with $Cb_2O_5 : TiO_2$ between 1.2 and 1.3, and polycrase to those with ratio less than 1:4.

PROCEEDINGS OF SOCIETIES

THE MINERALOGICAL SOCIETY (ENGLAND)

Mineralogical Society, June 12, 1928. DR. G. T. PRIOR, F. R. S., President, in the chair.

PROF. F. SLAVIK and DR. L. J. SPENCER: *Place-names of mineral-localities in central Europe.* Many important mining districts in the former Austro-Hungarian monarchy are now in other countries and the localities are now know officially by other names. Lists are given for each county and province with equivalent place-names in the various languages (fifteen in all), together with a statement of the principal minerals from each locality. A key to the pronunciation of letters with diacritical marks and a glossary of geographical terms that enter into the construction of place-names are added.

DR. L. J. SPENCER: *Eleventh list of new mineral names.* The first list of this series was published in 1897 and gave all the names of minerals not in the sixth edition of Dana's "System of Mineralogy" (1892). Others have appeared every three years at the end of each volume of the "Mineralogical Magazine." They are intended as dictionary lists of new names rather than lists of new minerals. About 170 names are now added.

MR. A. F. HALLIMOND: *On the atomic volume relations in certain isomorphous series III.* In the preceding parts of the paper it was shown that the volume-differences in isomorphous series derived from the same group of eutropic elements stood in a constant ratio in all series, and that this relation could be used to calculate atomic volumes for the elements in the combined state. It is now shown that compressibilities agreeing with those determined by Slater for eleven alkali halides can be calculated from the atomic volumes already assigned to the combined elements, by means of the relations $\beta = V/K, \beta' = V'/K'$, where β, V, are the compressibilities and atomic volumes of the combined metals; β', V' those of the halogens. For all the metals K has the value -4×10^{-6}, for the halogens K' is approximately -2.5×10^{-6}. The compressibilities of the free metals, as well as the atomic volume relations and the compressibilities in the combined state, are shown to be consistent with relations of the type $pv = K$, already indicated by Richards for the free metals; K, the constant for the eutropic group, assuming a new value in each isomorphous salt-series. The atoms thus behave as regions of a perfect gas under a high pressure.

MR. H. COLLINGRIDGE: *On the determination of optic axial angles and crystal-forms from observations by the Becke Method in thin sections.* A suggested method of combining separate observations of different sections in one stereographic diagram and incidentally finding from the combined diagram the forms and axial ratios and optic axial angle of the crystal. The method is illustrated by an example of olivine in an olivine-basalt.

MR. S. I. TOMKEIEFF: *A contribution to the petrology of the Whin Sill.* In this paper are described certain rare varieties of the Whin Sill, such as the coarse gabbroidal rock, occurring in the form of bands within the mass of the normal dolerite, the coarse rock with red granophyric spots, the red felsitic veinlets, and spherical aplitic inclusions. A scheme of differentiation is applied to explain the origin of these varieties.

NOTES AND NEWS

NOMINATIONS FOR OFFICERS OF THE MINERALOGICAL SOCIETY FOR 1929.

The Council unanimously nominates the following officers of The Mineralogical Society of America for the year 1929:

PRESIDENT: Arthur L. Parsons, University of Toronto, Toronto, Canada.
VICE-PRESIDENT: Edward Wigglesworth, Boston Society of Natural History, Boston, Mass.
SECRETARY: Frank R. Van Horn, Case School of Applied Science, Cleveland, Ohio.
TREASURER: Alexander H. Phillips, Princeton University, Princeton, New Jersey.
EDITOR: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.
COUNCILOR: 1929–1932, Clarence S. Ross, United States Geological Survey, Washington, D. C.

The ninth annual meeting of the Society will be held December 27-29, 1928, in New York City, in conjunction with that of the Geological Society of America and other affiliated Societies. It is planned to publish in the December issue of the Journal a *preliminary* list of titles of papers to be presented before the Society at its annual meeting. In order to appear on the advance program titles of papers should be in the hands of the Secretary by *November 10.*

FRANK R. VAN HORN, *Secretary*

Professor L. W. Currier, associate professor of mineralogy at the Missouri School of Mines, has been appointed associate professor of engineering geology at Purdue University.

Dr. Victor T. Allen, assistant professor of geology in the University of California, has been appointed assistant professor of geology at St. Louis University.

REVIEWS

THE PROPERTIES OF SILICA. ROBERT B. SOSMAN. 856 pages, with 187 figures and 113 tables. Published December 1927 by The Chemical Catalog Company, Inc.,*New York.* $12.50.

This book appears as Number 37 of the American Chemical Society Monograph Series. It is divided into eight parts as follows: (1) Fundamentals, (2) Phases and Their Transformations, (3) Symmetry and Structure, (4) Thermal Energy, (5) Mechanical Energy, (6) Silica in the Electric and Magnetic Fields, (7) Silica in the Periodic Electro-magnetic Field, (8) Applications.

The physical and crystalline properties of eight modifications of silica, together with their transformations, stability, and inversion phenomena, are elaborately treated. Low-quartz, high-quartz, low-tridymite, lower high-tridymite, upper high-tridymite, low-cristobalite, high-cristobalite, and silica glass are considered. Beside these there are more than two score references to chalcedonic silica, its properties, occurrences, inversions, and stability. Opal is not considered by the author as within the scope of the book, as it belongs to the SiO_2:H_2O series. Lechateliérite is not mentioned.

The mechanical construction of the book is excellent. The printing, grade of paper used, and binding are very good. Figures are carefully prepared and clearly and accurately printed. The top of each page bears both the chapter and page number. The figures and bibliographic references are consecutively numbered for each chapter.

The many results of the research on silica conducted by Dr. Sosman and his associates at the Geophysical Laboratory of the Carnegie Institution and here published for the first time, the elaborate treatment of the structure of the silica molecule as shown by X-ray analysis, and the splendid bibliographies render the book of incalculable value to any mineralogist, or to the petrologist working in igneous rocks. The sedimentary petrologist and sedimentologist will find much of value and interest, but will be disappointed in the relatively small amount of matter dealing with the interrelations of low-quartz, chalcedony, and opal.

The general and economic geologists will find much of value in the chapters of Part 8. These chapters include: Geological Applications, Silica Minerals and Rocks, Industrial Applications of Silica, The Chemical Uses, The Physical Uses, and Silica Refractories.

Frederick A. Burt

GALLIUM I. ARC SPECTROGRAPHIC DETECTION AND ESTIMATION OF GALLIUM. II. EXTRACTION OF GALLIUM FROM LEPIDOLITE. Jacob Papish and Donald A. Holt, *Jour. Phys. Chem.*, Vol. XXXII, pp. 142–147, Jan. 1928.

GERMANIUM XXV. ARC SPECTROGRAPHIC DETECTION AND ESTIMATION OF GERMANIUM. OCCURRENCE OF GERMANIUM IN CERTAIN TIN MINERALS. ENARGITE AS A POSSIBLE SOURCE OF GERMANIUM. Jacob Papish, F. M. Brewer and Donald A. Holt. *Jour. Am. Chem. Soc.*, Vol. **49**, pp. 3028–3033, 1927.

A method is presented for the arc spectrographic detection and estimation of gallium. Artificial graphite rods are available for spectroscopic work which are of a very high degree of purity and the intensity and number of lines which the impurities produce are generally low. The spectrum given by these electrodes consist of lines and bands due to Mg, Na, Ca, Li, Si, Fe and Mn, as well as those due to carbon. While one gallium line is coincident with an iron line the latter is of low persistence and if visible many other lines due to iron should be present.

A carefully prepared gallium solution of great purity was used in different concentrations in the experimental work. Definite portions of each solution were added to the anode of the D. C. arc, fresh electrodes being used in each test. Spectral lines were observed at the highest concentration which became faint, very faint or missing at succeeding lower concentrations of the test solution. As a result of this experimental work it was possible to estimate the quantity of gallium, if present, in fifty-five minerals.

Lepidolite, from San Bernardino County, California; microcline, from California; microcline, from Virginia; and tourmaline, from San Diego County, California, contained the largest quantity of gallium of the minerals examined. This amount was expressed as "large trace."

In the case of the lepidolite, gallium was extracted by a new method. One kilogram of lepidolite yielded 0.0887 gm. of Ga_2O_3. The gallium content of the mineral is thus very close to 0.007 per cent.

In the second paper germanium has been detected and estimated by a similar method. Enargite, Santa Fé Mine, Chiapas, Mexico, was estimated to contain more than 0.1 per cent Ge. Enargite, Butte, Montana, 0.01 per cent Ge. Enargite, Central City, Colorado, and enargite, Braden Copper Company, Chile, more than 0.01 per cent. A cassiterite from north of Battle Mountain, Nevada, was estimated to contain more than 0.005 per cent Ge.

While the germanium content of enargite is less than that of the rare minerals argyrodite, canfieldite and germanite, it can be used as a source of this element on account of its much greater abundance. GeO_2 was extracted from two of the enargites.

E. E. FAIRBANKS

NEW MINERAL NAMES

Antamokite

Antamokite, a new telluride discovered in the Phillipines. *Eng. Min. Jour.*, (Reported by J. S. Colbath). **125**, 616, 1928.

NAME: From the town of *Antamok*, near which the mineral was found.

CHEMICAL PROPERTIES: A telluride of gold and silver. Analysis not given. Contains no lead, copper or antimony.

PHYSICAL PROPERTIES: Color bluish-grayish white. Streak dark gray. H. low, probably between 2 and 3.

METALLOGRAPHIC PROPERTIES: HNO_3 slowly tarnishes it slightly dark and rubs clean. Upon long interaction it becomes pitted. HCl, KCN, KOH are negative. $FeCl_3$ immediately tarnishes the mineral iridescent and remains so after rubbing. $HgCl_2$ slowly tarnishes it yellow and rubs faint yellow.

OCCURRENCE: Found in quartz veins in vugs in andesite associated with tetrahedrite, chalcopyrite and a little pyrite.

W. F. FOSHAG.

Tikhvinite

J. M. ANSHELESS AND N. J. VLODAVETZ: New Strontium Mineral from Bauxite Deposits in Tikhvin district, Russia. *Mem. Soc. Russ. Mineral.*, 2d series, **56**, 53-60, 1927. (Russian with English summary).

NAME: From the locality, *Tikhvin* district, Russia.

CHEMICAL PROPERTIES: A sulfate-phosphate of strontium and aluminum. Formula: $2SrO \cdot 3Al_2O_3 \cdot P_2O_5 \cdot SO_3 \cdot 6H_2O$. Analysis: SiO_2 0.56; TiO_2 0.16; Al_2O_3 31.14; Fe_2O_3 2.25; SrO 24.43; P_2O_5 18.05; SO_3 8.47; H_2O 12.54. Sum 97.60. Insoluble in acids.

PHYSICAL AND OPTICAL PROPERTIES: Color white. Optically anisotropic. $n=1.62$. H.=4.5. Sp. Gr. 3.32.

OCCURRENCE: Found as microcrystalline masses having the size of peas filling cavities in bauxite.

DISCUSSION: A well defined member of the alunite-beudantite group, corresponding to a sulfate-hamlinite.

W. F. F.

Slavikite

Rudolf Jirkovsky and František Ulrich: Slavíkit, nový minerál. (Slavikite, a new mineral). *Věstník Státního Geol. Ústavu Česko-slovenské Republiky*, **2,** 345-351, 1926.

Name: In honor of F. *Slavik*, Director of the Mineralogical Laboratory of the University of Prague.

Chemical Properties A hydrous sulfate of ferric iron, soda and potash: $(Na,K)_2SO_4 \cdot 2Fe_5(OH)_3 \cdot (SO_4)_6 \cdot 63H_2O$. Analysis: SO_2 34.06, Fe_2O_3 20.08, Al_2O_3 4.29, CaO 0.01, Na_2O 1.63, K_2O 0.57, H_2O+ 35.66, H_2O- 3.10, insol 0.52. Total 99.92.

Crystallographic Properties: Hexagonal, rhombohedral. Minute crystals with the rhombohedron $(10\bar{1}1)$ and the base. $c=1.03$.

Physical and Optical Properties: Color greenish yellow. Pleochroism distinct, ω lemon yellow, ϵ almost colorless. Optically negative, $\omega=1.530$, $\epsilon=1.506$. Sp. Gr. 1.905.

Occurrence: Found as a weathering product of pyrite, associated with halotrichite, pickeringite, gypsum and a fibrous iron magnesium sulphate at Valachov hill, near Skřivan, Bohemia.

W. F. F.

Viterbite

Ricardo Lleras Codazzi: Notas mineralogicas y petro-graficas. (Mineralogical and petrographical notes). *Bibliotheca del Museo Nacional, Bogota,* **1925,** p. 26. (*Abstr. Bull. Soc. Fran. Min.*, **50,** 57-58, 1927).

Name: From the locality, Santa Rosa de *Viterbo.*

Chemical Properties: A silicophosphate of aluminum. Analysis: SiO_2 21.00, P_2O_5 6.00, Al_2O_3 40 00, Fe_2O_3 2.30, H_2O 30.70. Total 100.00.

Physical and Optical Properties: Isotropic. H=2.5, Sp. Gr. 1.9.

Occurrence: Found as a pulverulent mass at Santa Rosa de Viterbo, state of Boyaca, Colombia.

W. F. F.

Fraiponite

G. Césaro: Sur la fraiponite, silicate basique hydrate de zinc et d'aluminum. (Fraiponite, a basic hydrated silicate of zinc and aluminum). *Ann. Soc. Geol. Belgique*, **50,** 106–110, 1927. First described but not named by Césaro: *Ann. Soc. Geol. Belgique,* **10,** 111, 1883.

Name: In honor of Julien and Charles *Fraipon.*

ChemicalProperties: A hydrous silicate of zinc and aluminum. $8ZnO \cdot 2Al_2O_3 \cdot 5SiO_2 \cdot 11H_2O$. Analysis (by Pisani): SiO_2 20.1, Al_2O_3 13. 9, ZnO 47. 0, H_2O 13.2, CaO 2.00, CO_2 3.8. Sum 100.00. Easily and completely soluble in nitric acid. Gelatinizes upon evaporation. Fuses easily to a white enamel.

Physical and Optical Properties: Color yellowish white. Luster silky. Biaxial, negative, with the plane of the optical axes parallel to the fibers. Elongation positive.

Occurrence: Found as crusts of fibers 4–10 mm. thick on smithsonite. Resembles asbestus. Locality unknown but believed to be one of the mines of Vieille-Montagne, Belgium.

W. F. F

Tanatarite

O. A. Petrushkevich: (On a New Mineral Variety of the Diaspor Group). *Bull. Geol. Min. Circle, Ekaterinoslav Mining Institute,* No. **2**, pp. 17–20, 1926. (Abstr. *Min. Abstr.*, **3**, 237, 1927).

Name: In honor of Prof. Josef *Tanatar* of the Ekaterinoslav Mining Institute.

Chemical Properties: A hydrous oxide of aluminum. Analysis: Al_2O_3 74.25, Fe_2O_3 1.44, MgO 1.72, CaO 3.09, SiO_2 3.72, H_2O 15.02. Sum 99.24.

Crystallographic Properties: Monoclinic.

Physical and Optical Properties: Biaxial, $2V=51°–60°$; $\alpha=1.70$, $\gamma=1.75$. Sections cut normal to the acute bisectrix give extinction angles up to 30° with the trace of the perfect cleavage. Elongation negative. Sp. Gr. 3.385. $H=6\frac{1}{2}$.

Occurrence: Found in crevices in chromite occurring in talc and chlorite schists with chrome tourmaline, topaz (?), periclase, fuchsite, and uvarovite.

Discussion: (Apparently the same as kayserite. Cf. *Am. Mineral.*, **8**, 187, 1923).

W.F.F.

ADDITIONAL DATA

Schafarzikite

L. Tokody: Contributions to the knowledge of the crystallographical and physical properties of schafarzikite. *Zeit. Kryst.*, **62**, 123–126, 1925. (See *Amer. Mineral.*, **6**, 173, 1921).

Crystallographic Properties: New forms *m* (110) and *p* (111). A basal cleavage is also noted.

Physical and Optical Properties: Color red to reddish brown. Luster metallic, opaque. Streak brown. Thin plates yellow in color, thicker ones yellow to reddish brown and transparent. Pleochroism $\omega=$straw yellow, ϵ brownish yellow. *n* higher than 1.740. Birefringence weak. $H=3.5$. Sp. Gr. about 4.3.

W. F. F.

Arakawite

T. Ito: Die Kristallisations verhältnisse von Arakawite (The crystal relations of Arakawite). *Zeit. Kryst.*, **65**, 305–308 (1927).

New measurements on arakawite from Japan (cf. *Am. Mineral*, **8**, 37, 1923) give $a:b:c=0.734:1:0.956$, $\beta=76°10'$, demonstrating its isomorphism with vezelyite. [The mineral kipushite (cf. *Am. Mineral.*, **12**, 326, 1927) is identical with arakawite, the second orientation of Buttgenbach with $a:b:c=0.954:1:739$, $\beta=77°6\frac{1}{2}'$ having the dome *e* of arakawite the prism *m* of kipushite].

W. F. F.

Chevkinite

A. Boldereff: Étude cristallographique de la tscheffkinite de l'Oural. (Crystallographic Study of Chevkinite from the Urals). *Bull. Soc. Fr. Min.*, **48**, 120-127 (1925).

Crystallographic Properties: Monoclinic with the forms (100), (010), (001), (111), (101), (201), (110), (112).

W. F. F.

Potarite

L. J. Spencer: Potarite, a new mineral discovered by the late Sir John Harrison in British Guiana. *Mineral. Mag.*, 21, No. 120, pp. 397–406, 1928. (Cf. *Am. Mineral.*, **10**, 333, 1925).

Chemical Properties: A compound of palladium and mercury, Pd Hg. The variations in the composition given in the previous papers are suggested to be due to the fact that some of the nuggets had been previously heated. Soluble in nitric acid to a brown solution.

Crystallographic Properties: Isometric, in octahedrons.

Physical Properties: Sp. Gr. 15.0–16.1. H=3½ Brittle.

W. F. F.

REDEFINITION OF SPECIES

Nontronite

Esper S. Larsen and George Steiger: Dehydration and Optical Studies of Alunogen, Nontronite and Griffithite. *Amer. Jour. Sci.*, **15**, 4–15, 1928.

Chemical Properties: $Fe_2O_3 \cdot 3SiO_2 \cdot nH_2O$. Variable, especially with regard to its water content. A new analysis of material from Woody, California (by Steiger) gives: SiO_2 47.51, TiO_2 none, Al_2O_3 0.37, Fe_2O_3 35.17, FeO none, CaO 2. 50, MgO 1.40, K_2O 0.20, Na_2O 0.10, $H_2O(-)$7.16, $H_2O(+)$5.90, SrO none. Sum 100.16.

Optical Properties: On material of above analysis: Color dark olive green to dark olive buff. Pleochroism strong, X=pale yellow, Y=olive green, Z=yellow green. Biaxial negative with small axial angle and rather strong dispersion. $\alpha=1.56\pm0.01$, $\beta=1.585\pm0.01$, $\gamma=1.585\pm0.01$. Indices of refraction variable for β, 1.585 for 13.06 per cent. H_2O to 1.69 for 1.80 per cent H_2O.

Discussion: Nontronite is the iron analogue of beidellite (cf. *Am. Mineral.*, **11**, 167, 1926) with which it forms an isomorphous series. W. F. F.